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Modular handover algorithm for 5G HetNets with comprehensive load index

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Abstract

Most existing handover decision system (HDS) designs are monolithic, resulting in high computational cost and unbalance of overall network. A novel modular handover algorithm with a comprehensive load index for the 5th generation (5G) heterogeneous networks (HetNets) is proposed. In this paper, the handover parameters, serving as the basis for handover, are classified into network's quality of service (QoS) module, user preference (UP) module and degree of satisfaction (DS) module according to the new modular HDS design. To optimize switching process, the comprehensive network load index is deduced by using triangle module fusion operator. With respect to the existing handover algorithm, the simulation results indicate that the proposed algorithm can reduce the handover frequency and maintain user satisfaction at a higher level. Meanwhile, due to its block calculation, it can bring about 1.4 s execution time improvement.

Keywords 5G HetNets, handover, modular HDS, comprehensive load index

1 Introduction

Over the past few years, the increasing growth of mobile data traffic and intelligent terminal leads to the fact that current long term evolution (LTE) network cannot meet the demand of new multimedia services. 5G, the next generation wireless network, should outperform LTE in terms of metrics such as system capacity, spectrum utilization and connection speed. In addition to that, future wireless network architectures are envisaged to comprise of an integration of multiple wireless technologies such as 5G cellular wireless network, LTE, wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMax). They will maximize their own advantages that meet users' demands to ensure the provision of advanced services and reduced costs for both operators and users [1], and allow user equipment (UE) to have seamless mobility.

Fig. 1 illustrates architecture for 5G HetNets, with UE_1, UE_2 and UE_3 using different traffics.

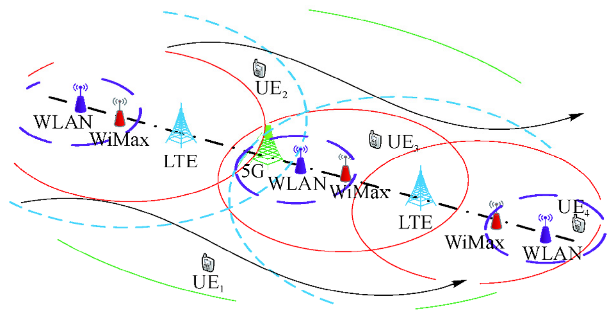

Fig. 1 Heterogeneous wireless network

In Fig. 1, when UE moves across different service areas, vertical handovers become necessary in order to maintain connectivity. To ensure the roaming and seamless vertical handover of UE in such environment, it is extremely essential to design a sufficiently smart HDS.

A number of schemes are carried out to solve vertical handover and related some techniques during several years. In Ref. [2], Singhrova et al. compared traditional handover decision strategies, and concluded that these methods are

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not sufficient to make a vertical handover decision. Queuing theory is used to trigger handover between HetNets in an advanced algorithm [3], which brings performance improvement of ping-pong effects. However, with the gradual rising of users, handover latency increases. Network selection can be initialized by user end [4] or can be based upon measurements of link quality by the network side [5], it tends to solve the handover problem by searching for the optimal solution. Based on handover optimization [6–7] or user behavior [8], UE can make the right choice to how to access optimal network in HetNets.

After all, UE aims to join the best access point, and network selection turns into a decision making problem with multiple options and attributes. Recently, multi-attribute decision making (MADM) is often used in HetNets [9–12], however, it becomes inefficient in execution time because of its traditional monolithic HDS designs. As user-centric research is increasingly crucial in 5G HetNets, load balancing is an important element to offer good quality of experience (QoE) for UE. In Ref. [13], yang et al. set up a fixed load threshold to adjust handover hysteresis margin to reduce failure rate. The effect of dynamic load balancing for each network is put forward in Ref. [14]. These schemes are limited to single network scenario, therefore, the overall load level needs to be known in HetNets.

In this paper, all the above problems are considered, and a new modular handover algorithm with comprehensive load index is presented. The purpose of new modular HDS is to reduce the computational complexity. In terms of load balancing, the algorithm introduces triangle module fusion operator to estimate the load index comprehensively in 5G HetNets.

The rest of this paper is outlined as follows. In the next section, the proposed modular handover algorithm with comprehensive load index will be discussed. Performance analyses are provided in Sect. 3. Sect. 4 gives the simulation results. Finally, Sect. 5 concludes this paper.

2 Modular handover algorithm with comprehensive load index

2.1 Modular HDS

In the present study of MADM handover algorithm, a traditional monolithic HDS is widely used, which is shown in Fig. 2. All handover parameters are calculated by a single engine in monolithic HDS, then the final score of each candidate wireless network is obtained. Since an increasing number of handover parameters give rise to generating computational complexity and long execution time, it is extremely necessary to design a new intelligent HDS, which can be satisfied with higher demand for 5G HetNets.

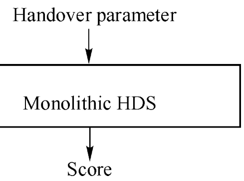

Fig. 2 Monolithic HDS design

Combining handover requirements of network side and user end, the new architecture of modular HDS is shown in Fig. 3. In Fig. 3, Q denote the output of NQ module, P denote the output of UP module. The modular HDS consists of three engines, networks' QoS (NQ) module, UP module and DS module. The handover parameters are categorized into groups according to modular HDS design, and each module is dealt by different algorithms simultaneously, which can reduce the computing time. The three modules jointly determine the final rank of candidate wireless networks.

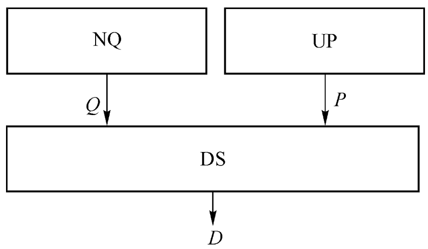

Fig. 3 Modular HDS design

2.2 NQ module

The NQ module determines the QoS provided by each candidate wireless network. Consider UE moving cross HetNets that support L types of traffics, with M available network alternatives and N network parameters. Thus, $T=\{T_1,T_2,...,T_l,...,T_L\}$ is the set of L traffics types, $A=\{A_1,A_2,...,A_i,...,A_M\}$ is the set of network alternatives and $H=\{H_1,H_2,...,H_j,...,H_N\}$ is the set of handover parameters. Each parameter's weight vector with respect to each traffic is given by: $\boldsymbol{W}^l=(W_1^l,W_2^l,...,W_j^l,...,W_N^l)$, $l=1,2,...,L$, where each W_j^l is the weight assigned to the handover parameter H_j by the traffic T_l,